

WHAT IS CLAIMED IS:

1. A manipulator operative in a master/slave operative mode, comprising:

a master unit commanding an operation;

a slave unit having a work unit ;

a detector detecting the orientation of the master unit and the orientation of the slave unit; and

a control device controlling the slave unit in response to the command from the master unit,

wherein the control device includes:

a function of determining a non-master/slave operative mode or a master/slave operative mode;

a function of calculating a difference between the orientation of the master unit and the orientation of the slave unit; and

a function of comparing the absolute value of the difference with a preset reference value; and depending upon the result of the comparison, determining a normal master/slave operative mode or a transitional master/slave operative mode, in said master/slave operative mode, said transitional master/slave operative mode is a transitional mode from the non-master/slave operative mode to the master/slave operative mode.

2. The manipulator according to claim 1 wherein the control device selects the normal master/slave operative mode when said absolute value is smaller than the reference value, and selects the transitional master/slave operative mode when said absolute value is larger than the reference value.

3. The manipulator according to claim 2 wherein, in case said absolute value is larger than the reference value,

when the master unit is controlled to change the orientation thereof away from the orientation of the slave unit, the control device generates an accelerated follow target as a target orientation value of the slave unit to enable the orientation of the slave unit to catch up with the orientation of the master unit, and

when the master unit is controlled to change the orientation thereof toward the orientation of the slave unit, the control device generates a

decelerated follow target as the target orientation value of the slave unit to enable the orientation of the master unit to catch up with the orientation of the slave unit.

4. The manipulator according to claim 3 wherein, in case the orientation change ratio of the master unit is zero, the control device generates a stop target to stop the slave unit.

5. The manipulator according to claim 1 wherein, upon judging whether the orientation control of the master unit is done to change the master unit away from the slave unit or toward the slave unit, the control is judged to move the master unit away from the slave unit when D is positive, and judged to move the master unit toward the slave unit when D is negative, said D is given by

$$D = \Delta\theta_m \times d$$

where $\Delta\theta_m$ is the time difference of the orientation of the master unit, and d is the angular difference obtained by subtracting the orientation θ_s of the slave unit from the orientation θ_m of the master unit.

6. The manipulator according to claim 1 wherein the master unit and the slave unit have the relation expressed by $\theta_{mq} = \beta\theta_{sq}$ where θ_{mq} is the moving amount of the master unit, θ_{sq} is the moving amount of the slave unit, and β is 1, and the slave unit moves by a moving amount equal to the moving amount of the master unit.

7. The manipulator according to claim 6 wherein the control device can change the time difference $\Delta\theta_s$ of the target value of the slave unit by a parameter α to satisfy the equation

$$\Delta\theta_s = \alpha\Delta\theta_m$$

where $\Delta\theta_m$ is the time difference of the orientation of the master unit, $\Delta\theta_s$ is the time difference of the target value of the slave unit, and α is a selectable parameter.

8. The manipulator according to claim 7 wherein the control device selects the normal master/slave operative mode when said absolute value is smaller than the reference value, and selects the transitional master/slave

operative mode when said absolute value is larger than the reference value.

9. The manipulator according to claim 8 wherein, in case said absolute value is larger than the reference value,

when the master unit is controlled to change the orientation thereof away from the orientation of the slave unit, the control device generates an accelerated follow target as a target orientation value of the slave unit to enable the orientation of the slave unit to catch up with the orientation of the master unit, and

when the master unit is controlled to change the orientation thereof toward the orientation of the slave unit, the control device generates a decelerated follow target as the target orientation value of the slave unit to enable the orientation of the master unit to catch up with the orientation of the slave unit.

10. The manipulator according to claim 9 wherein the control device sets the parameter α larger than 1 when the master unit is controlled to change the orientation thereof away from the orientation of the slave unit, and set the parameter α to a value greater than or equal to zero and smaller than 1 when the master unit is controlled to change the orientation thereof toward the orientation of the slave unit.

11. The manipulator according to claim 7 wherein the control device has the function to select the operating manner in the transitional master/slave operative mode by setting the parameter.

12. The manipulator according to claim 7 wherein the control device can set the parameter individually for each axis of the master unit.

13. The manipulator according to claim 1 wherein the master unit and the slave unit have the relation expressed by $\theta_{mq} = \beta \theta_{sq}$ where θ_{mq} is the moving amount of the master unit, θ_{sq} is the moving amount of the slave unit, and β is a value other than 1, and the slave unit moves by several times or one part of several divisions of the moving amount of the master unit.

14. The manipulator according to claim 13 wherein the control

device can change the time difference $\Delta\theta_s$ of the target value of the slave unit by a parameter α_{ext} to satisfy the equation

$$\Delta\theta_s = \alpha_{ext}\Delta\theta_m$$

where $\Delta\theta_m$ is the time difference of the orientation of the master unit, $\Delta\theta_s$ is the time difference of the target value of the slave unit, and α_{ext} is a selectable parameter.

15. The manipulator according to claim 14 wherein the control device selects the master/slave operative mode when said absolute value is smaller than the reference value, and selects the transitional master/slave operative mode when said absolute value is larger than the reference value.

16. The manipulator according to claim 15 wherein, in case said absolute value is larger than the reference value,

when the master unit is controlled to change the orientation thereof away from the orientation of the slave unit, the control device generates an accelerated follow target as a target orientation value of the slave unit to enable the orientation of the slave unit to catch up with the orientation of the master unit, and

when the master unit is controlled to change the orientation thereof toward the orientation of the slave unit, the control device generates a decelerated follow target as the target orientation value of the slave unit to enable the orientation of the master unit to catch up with the orientation of the slave unit.

17. The manipulator according to claim 16 wherein the control device sets the parameter α_{ext} to satisfy

$$0 \leq \alpha_{ext} \leq \beta$$

when the master unit is controlled to change the orientation thereof toward the orientation of the slave unit, and set the parameter α_{ext} to satisfy

$$\alpha_{ext} \geq \beta$$

when the master unit is controlled to change the orientation thereof away from the orientation of the slave unit.

18. The manipulator according to claim 14 wherein the control device has the function to select the operating manner in the transitional

master/slave operative mode by so setting the parameter.

19. The manipulator according to claim 14 wherein the control device can set the parameter individually for each axis of the master unit.

20. The manipulator according to claim 1 wherein the control device has the function to change the operative mode between the transitional master/slave operative mode and the normal master/slave operative mode which is preset.

21. The manipulator according to claim 1 wherein the control device has the function to employ an angle of orientation of the master unit falling in a read value non-sensitive region of control angles of the master unit in the master/slave operative mode, to use said angle of orientation of the master unit in the transitional master/slave operative mode, and the function to execute saturation processing of the target value of the slave unit after generating the target value by the operating manner determined in the transitional master/slave operative mode.

22. A control device of a manipulator working in a master/slave operative mode and having a master unit for commanding an operation, a slave unit having a work unit and operative in response to a command from the master unit, and a detector unit for detecting the orientation of the master unit and the orientation of the slave unit, comprising:

a function of calculating a difference between the orientation of the master unit and the orientation of the slave unit; and

a function of comparing the absolute value of the difference with a preset reference value, and switching the operative mode between a transitional master/slave operative mode and a normal master/slave operative mode depending upon the result of the comparison, the transitional master/slave operative mode being a transitional mode from a non-master/slave operative mode to the master/slave operative mode.

23. A method of control a manipulator working in a master/slave operative mode and having a master unit for commanding an operation, a slave unit having a work unit and operative in response to a command from

the master unit, and a detector unit for detecting a difference between the orientation of the master unit and the orientation of the slave unit, comprising:

calculating a difference between the orientation of the master unit and the orientation of the slave unit; and

comparing the absolute value of the difference with a preset reference value, and depending upon the result of the comparison, determining a normal master/slave operative mode or a transitional master/slave operative mode which is a transitional mode from a non-master/slave operative mode to the master/slave operative mode.